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L18: Entry 16 of 21 File: USPT Dec 18, 1979

US-PAT-NO: 4179739
DOCUMENT-IDENTIFIER: US 4179739 A

TITLE: Memory controlled process for railraod traffic management

DATE-ISSUED: December 18, 1979

INVENTOR-INFORMATION:

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U.S. PATENT DOCUMENTS

Search Selected Search ALL Clear

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
3953714	April 1976	Gabillard	364/436
3971018	July 1976	Isbister et al.	364/436
3976272	August 1976	Murray et al.	364/436
4023753	May 1977	Dobler	364/436
4066877	January 1978	Virnot et al.	364/426
4084241	April 1978	Tsumura	364/450

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PRIMARY-EXAMINER: Atkinson; Charles E.

ATTY-AGENT-FIRM: Charmasson; Henri J. A.

ABSTRACT:

A method for regulating vehicular traffic over a network of itineraries travelled by various vehicles such as railroad trains, or other public modes of transportation. On board, computer assisted vehicle control processes are advantageously combined with traditional time-table scheduling and modern centralized traffic control concepts. Simplified audio radio communications alleviate the need for intensive track equipment. Monitoring and signaling devices are limited to those dictated by safety rules and regulations. In order to limit to a minimum the exchange of data between each vehicle and the traffic control, a set of predetermined timetables are stored on board each vehicle. Traffic instructions are reduced to two elements, the identification of the assigned timetable and a time lag constant to be uniformly added to the time entries of the assigned time-table. The method relies on precise dead-reckoning equipment on board each vehicle which permits its operation in precise conformance with the assigned time-table. The dead-reckoning equipment which allows a continuous display of the exact location of the vehicle along its prescribed itinerary uses a combination of various conventional and novel techniques for the computation of the distance travelled. The most important of these techniques comprises the recognition along the itinerary of various planned and unplanned events which have been detected during previous experimental runs and recorded in coordination with their locations. Various cross-check and probabilistic choices are used in order to achieve a very high degree of accuracy and reliability of measurement. The method also contemplates the automatic control of the vehicle speed in function of prerecorded acceleration data, and of feedback information proportional to the time error computed in function of the assigned time-table and the dead-reckoning system display.

10 Claims, 18 Drawing figures

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Abstract Text (1):
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Application Filing Date (1):
19780213

Brief Summary Text (3):
The trend towards centralized traffic control operation of railroad networks, based on extensive train location equipment along the track, has been prompted by two factors. On one hand the traditional inability of trains to accurately determine their position between stations prevented their engineers from making, on their own, the acceleration or breaking decisions necessary to reach a predetermined point on time, or to avoid collisions. On the other hand the unavailability of practical and reliable audio radio equipment severely limited communications between train crews and traffic stations. The centralized traffic control has greatly improved the efficiency of networks formerly managed by the traditional time-table method. Under time-table programming, trains were constrained to run within predetermined schedules. These schedules however, had large safety margins to guard against possible interferences with other trains. The network traffic capacity was thus severely limited. Today the time-table method of traffic regulation can still be encountered over some simple and lightly travelled circuits.

Brief Summary Text (4):
The centralized method of traffic management, however, is not without disadvantages. Besides requiring a heavy investment in equipment and maintenance work, the method has other limitations. In spite of the repetitive nature of train schedules, the progress of a particular train over a frequently travelled itinerary is seldom similar from one run to the next. The train movement is subject to random pace variations dictated by the traffic control center in function of the current traffic condition over the network. The resulting braking and acceleration maneuvers increase the fuel consumption. Furthermore, the speed variations coupled with the uncertainty of the exact location of the train within a block create security risks. These risks can only be eliminated by increasing the minimum spacing between trains, thus causing additional delay, waste of energy and lower traffic capacity.

Brief Summary Text (5):
Today's radio communications have been tremendously improved. Electronic miniaturization allows for installation of computer assisted dead-reckoning system on board each train. The task of the traffic control centers could now be safely and very efficiently alleviated by returning to the train crews (or to the train auto-piloting system) some of the track monitoring and decision making operations.

Brief Summary Text (8):
The present invention teaches new method for accurately determining, on board a moving vehicle, its accurate position along an itinerary; and a new procedure for regulating its speed in order to meet its assigned schedule in response to said position determination. The method also teaches the use of stored control instructions (which may have been recorded during a previous run) in order to regulate the pace of the vehicle. Each vehicle can thus assume some of the control and decision-making normally concentrated at the traffic control center. More specifically the invention provides for storing on board each vehicle a set of predetermined time-tables. The time-tables are cross-checked two by two for compatibility and each vehicle is assigned a time-table and a time-lag to be added uniformly to the assigned time-table data. Accurate dead-reckoning equipment on board each vehicle provides a precise measurement of the vehicle compliance with its assigned time-table. The dead-reckoning equipment comprises conventional methods such as wheel revolution counters, and accelerometers. It comprises also the recognition along the itinerary of various planned and unplanned events which have been detected during previous runs and recorded in coordination with their location and timing data. Various cross-checks between sensors, auto calibration and statistical selection of data techniques are used to achieve a highly reliable position determination. The method also teaches the automatic piloting of the vehicle based on acceleration data recorded during experimental runs. These acceleration data are further combined with a signal proportional to the time error computed in function of the assigned time-table and the location displayed on the dead reckoning equipment.

Detailed Description Text (2):
Referring now to FIG. 1 of the drawing, there is shown the diagram of a hypothetical railroad network ABCDEF which comprises four itineraries. Let us assume that itinerary i (AEFB) is travelled from A to B by train Hi; itinerary j (DEFC) is travelled from D to C by train Hj; itinerary k (BFED) is travelled from B to D by train He; and itinerary 1 (CFEA) is travelled from C to A by train Hl. Let us assume also that the distances between locations ABCDE and F are those listed in meters in table G of FIG. 1, that train speeds are constant as listed in meters per second along with the length of each train in meters in table H of FIG. 1. Security regulations further dictate that the spacing between trains cannot at any time be less than 5 minutes. Given the above hypothesis, the regulation of such a network, according to the present invention may be achieved as explained below in order to process the four trains in the most direct method across the network, and with minimum supervision by the traffic regulating center.

Detailed Description Text (3):
Each curve of FIG. 2A represents the most direct and fastest time-table for the corresponding train over its assigned itinerary. However, the diagram of FIG. 2A assumes that all four trains start at the same time (t=o) which leads to several conflicts that must be avoided by establishment of priority between trains, adjustment of speed, stop and wait periods or other delaying methods. According to the teachings of this invention, a distinct time-lag TL is added uniformly to each time-table TT so that, when the time-tables are compared two by two, no conflict can be found. This condition may be expressed between, for instance, the time-table of trains Hi and Hj as follows:

Detailed Description Text (4):
if train Hi is to follow train Hj, and

Detailed Description Text (5):
if train Hj is to follow train Hi; wherein TLi and TLj are the time lags added to the time-tables of train Hi and Hj respectively, li and lj are the lengths of trains Hi and Hj respectively, and ai, aj, lij and bji are constant factors established in function of the itineraries and trains characteristics.

Detailed Description Text (6):
In our hypothesis ai, aj, ak and al are equal to the inverses of the speeds of train Hi, Hj, Hk and Hl respectively. The constant bij may be determined according to the formula:

Detailed Description Text (7):
Wherein Tcj is the time set in the basic time-table of the first train for passing at the "critical point" and Tci the time in the time-table of the second train corresponding to the same "critical point". For trains travelling in the same direction over a common path such as Hi and Hj from point E to point F, the critical point is the point of entry E if the first train is faster, and the point of exit F if the following train is faster. For trains travelling in opposite directions over a common path such as Hi and Hk, and trains Hj and Hl, the critical point is where the first train leaves the common section of tracks and where the second enters that common section.

Detailed Description Text (8):
FIG. 2B shows the basic time-tables of trains Hi and Hj and how bij is determined in order to delay Hi so that Hi will travel the common section safely after train Hj. Hj being faster than Hi, the point E is the critical point. According to those time-tables, Tci=800s, Tcj=800s, hence bij=SF=300s

Detailed Description Text (9):
FIG. 2C shows how bji is determined in order to delay train Hj so that it travels safely after Hi on the common path. The critical point is now F, Tcj=1200, Tci=1600 hence bji=1600-1200+300=700s.

Detailed Description Text (11):
A variety of 24 combinations of orders of priority is offered with 4 trains. Let us assume that the selected order is Hl, Hj, Hk, Hj. The time-lags to be assigned to the time-tables must meet the following conditions, starting with TLl=0:

Detailed Description Text (16):
FIG. 3 illustrates the resulting timing diagram for the entire network operation. New time-tables with modified itineraries, new trains or different train speeds could be introduced into the above scheme. Such additional time-tables would have to be checked two by two against each other and against the previously established ones according to the procedure just described. The procedure would yield a new set of time-lags to be communicated to the respective trains in order to establish a

new overall workable schedule for the network. Conversely, a vehicle crew may have to ask by radio communication, for agreement on an increased time-lag if for any reason it has been delayed, or they may report they had to switch to a lower grade time-table (slower time-table).

Detailed Description Text (17):
The present method of traffic management may be readily adapted to networks already equipped with standard block signaling systems for avoiding train collisions. Rather than using a security factor SF in the form of a time constant as previously described, the values of bij are established in function of the restrictive signaling generated by the immediately preceeding train.

Detailed Description Text (18):
The following example illustrates a method for determining bij on the previously described network subdivided in 1000 meters blocks, for trains Hi and Hj sharing a common path EF. Referring now to FIG. 15, given the slow speed of Hi, the distant signal at point M being the first restrictive signal to affect Hi if Hj has not cleared point E, bij is computed as follows: bij=Tcj-Tci where Tcj is the time at which Hj clears point E and Tci is the time when Hi clears point M. For the sake of simplicity, the above example assumes that both trains have constant speeds. It should be noted however, that the same method applies to variable speed time-tables, with or without safety signaling. Interference limit conditions for a vehicle Hi following a vehicle Hj without having to slip off its assigned time-table may always be expressed in condensed form through two constant such as aj and bij.

Detailed Description Text (23):
In a second memory 9, are stored the instantaneous acceleration or deceleration commands to be applied to the vehicle in relation to the vehicle position px. These commands are also cross-related in the memory 10 to the times tx corresponding to the position px according to the assigned time-table. These acceleration or deceleration commands can be computed a priori and entered in the laboratory. Preferably they are recorded during an experimental run of the vehicle over the corresponding itinerary, according to the procedure illustrated in FIG. 13. During subsequent runs command datum .gamma.ex is extracted from the memory 9 in function of the position coordinate px issued by the dead-reckoning process 3, to which a correction factor corresponding to the product of the speed vx by the response time, TR of the vehicle to acceleration or deceleration commands is added at 8. Command datum .gamma.et is extracted from the memory 10 in function of the time te derived from the clock after adding the response time TR to the time Ti, in 7, so that te=tc+TR-TL. A selector circuit 13 allows .gamma.ex to reach adder circuit 14 only when .gamma.ex value is negative or corresponding to a deceleration command. The command .gamma.et is fed to adder 14 only when it is positive and corresponding to an acceleration command. The command data .gamma.ex and .gamma.et should theoretically be sufficient to allow the vehicle to faithfully duplicate the experimental or theoretical run the characteristics of which have been stored in the memories 2 and 9. However, the inherent inaccuracy of the various organs of the vehicles would tend to cause a drift away from the time-table schedule. An additional acceleration or deceleration component .gamma.x is thus generated in 12 in function of the time error .DELTA.tx according to the formula:

Detailed Description Text (26):
Various types of distance measurement techniques and devices may be advantageously used within the scope of this invention. For the sake of explanation, an acceleration technique and a wheel revolution counter technique will be specifically discussed. The first measurement chain comprises a wheel revolution counter 15 associated with a long term drift correction circuit 16 to indicate the estimated distance travelled pc.

Detailed Description Text (27):

The second measurement chain comprises an accelerometer 19 which is located on the vehicle structure so as to give an indication of the longitudinal acceleration applied to it. In a train locomotive this accelerometer should be located near the center of the moving body in order to reduce the effect of the lateral acceleration experienced during the negotiating of curves. In order to compensate for slopes and suspension deflections, a tilting correction generated by a gyroscope 29 is added to the accelerometer 19 output. The acceleration data are fed to a first integrator circuit 20 at the output of which the speed vx of the vehicle is read and displayed at 26. A second integrator circuit 21 is used to obtain the estimated distance travelled py. An increment selector 23 periodically selects the distance increment indicated during the current measurement period from either pc or py. This incremented period may conveniently be in the order of one second. The selection function may be the sum of Q.sub.Pc and (1-Q).sub.Py where Q is the weight factor attributed to the revolution counter data. The selected increment is then added in 24 to the content px of a position display register 25 in order to generate the current position coordinates which is immediately entered into the display register 25 in place of the previous reading.

Detailed Description Text (28):
It should be noted that the wheel-revolution counter and the accelerometer constitute two measurement techniques which appropriately complement one another. The accelerometer usually gives a reliable measure but its twice integrated output signal is subject to drifting. It is known that during periods of high acceleration or on uphill ramps, the traction wheels of a vehicle are subject to spinning. During the deceleration process the wheels are subject to skidding. The revolution-counter is thus a poor gauge of the distance travelled during these periods; but can safely be relied upon during long periods of constant speed or of low power application, to provide precise measurement on the basis of which the accelerometer can be recalibrated. The increment selector 23 operates in function of the raw, absolute value of acceleration and gives more weight to distance increments from the wheel revolution-counter in inverse proportion to the amplitude of the accelerometer output. A comparator circuit 22 is further added in order to generate a correction factor for the accelerometer and the speed indicator 26 in function of the error detected between pc and py during periods when the wheel revolution-counter can be expected to yield very reliable data.

Detailed Description Text (33):
FIG. 9 also illustrates the block diagram of the process followed in correcting the slow drift error caused by variations in the wheel circumference due to wear and temperature variations.

Detailed Description Text (34):
The wheel circumference factor W (multiplied in 32 by the number of revolutions N indicated by the counter 15) is quasicontinually adjusted by a minute correction factor .epsilon. added to it at 33. The correction factor .epsilon. is a function of the correction C applied to the display register 25 upon detection of a check point. This correction is computed in the correction circuit 31. A low-pass, integrating type filter 30 may be advantageously installed between the circuit 31 and the adder circuit 33 in order to stabilize the corrective system loop. The exact location coordinates pex of each check point Ex can be determined by survey and written into the memory 17 in the laboratory. These coordinates can also be recorded during an experimental run according to the following procedure.

Detailed Description Text (39):
When identity of signals is found between the information extracted from the memory 17 and the information issued by the sensing equipment 38-39, the corresponding location coordinate Pxn which lies between Pxm and Pxr is transmitted to the correction factor generator circuit 36. In the correction factor generator circuit 36, the location coordinate Pxn is compared to the estimated location px and a correction value C is generated according to a function similar to that illustrated

by curve C of FIG. 8. The correction value is then added at 37 to the estimated position coordinate px. The resulting corrected coordinates are then entered into the display register 25. The correction value C is also used to reset the variable statistical factor used in the statistical limit circuit 34.

CLAIMS:

5. The method claimed in 4 which further comprises:

(a) recording in a memory during said experimental run, an identification code for each said event in coordination with its location of occurrence coordinates;

(b) reading at least one of said events identification code during subsequent scheduled runs from said memory according to an address margin determined in function of the estimated location coordinates held in said register combined with statistical factors which are modified in function of the current estimated accuracy of the coordinates held in said register;

(c) comparing the identification code of the event being detected with the identification code being read out from the memory;

(d) upon detecting similarity between said identification codes, generating a correction factor to be applied to the contents of said register where said correction factor is a continuous non-linear function of the difference between the coordinates stored in the register and the prerecorded location coordinates of the detected event.

8. The method claimed in claim 2 wherein step 2b comprises:

measuring said distance by means of at least one accelerometer, the output of which is twice integrated, and by means of at least one wheel revolutions counter, wherein the accelerometer generated data are given more weight during periods of acceleration and deceleration and the revolutions counter data are given more weight during periods of constant speed or minor acceleration and deceleration.

9. The method claimed in 8 which further comprises:

modifying the wheel circumference factor used to calculate the distance travelled from the wheel revolution counters data, by a correction factor adjusted periodically in function of the error between said data and measurement derived from at least one other means.

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Brief Summary Text (3):
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Each curve of FIG. 2A represents the most direct and fastest time-table for the corresponding train over its assigned itinerary. However, the diagram of FIG. 2A assumes that all four trains start at the same time (t=o) which leads to several conflicts that must be avoided by establishment of priority between trains, adjustment of speed, stop and wait periods or other delaying methods. According to the teachings of this invention, a distinct time-lag TL is added uniformly to each time-table TT so that, when the time-tables are compared two by two, no conflict can be found. This condition may be expressed between, for instance, the time-table of trains Hi and Hj as follows:

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if train Hi is to follow train Hj, and

Detailed Description Text (5):
if train Hj is to follow train Hi; wherein TLi and TLj are the time lags added to the time-tables of train Hi and Hj respectively, li and lj are the lengths of trains Hi and Hj respectively, and ai, aj, lij and bji are constant factors established in function of the itineraries and trains characteristics.

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Wherein Tcj is the time set in the basic time-table of the first train for passing at the "critical point" and Tci the time in the time-table of the second train corresponding to the same "critical point". For trains travelling in the same direction over a common path such as Hi and Hj from point E to point F, the critical point is the point of entry E if the first train is faster, and the point of exit F if the following train is faster. For trains travelling in opposite directions over a common path such as Hi and Hk, and trains Hj and Hl, the critical point is where the first train leaves the common section of tracks and where the second enters that common section.

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FIG. 2B shows the basic time-tables of trains Hi and Hj and how bij is determined in order to delay Hi so that Hi will travel the common section safely after train Hj. Hj being faster than Hi, the point E is the critical point. According to those time-tables, Tci=800s, Tcj=800s, hence bij=SF=300s

Detailed Description Text (9):
FIG. 2C shows how bji is determined in order to delay train Hj so that it travels safely after Hi on the common path. The critical point is now F, Tcj=1200, Tci=1600 hence bji=1600-1200+300=700s.

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A variety of 24 combinations of orders of priority is offered with 4 trains. Let us assume that the selected order is Hl, Hj, Hk, Hj. The time-lags to be assigned to the time-tables must meet the following conditions, starting with TLl=0:

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FIG. 3 illustrates the resulting timing diagram for the entire network operation. New time-tables with modified itineraries, new trains or different train speeds could be introduced into the above scheme. Such additional time-tables would have to be checked two by two against each other and against the previously established ones according to the procedure just described. The procedure would yield a new set of time-lags to be communicated to the respective trains in order to establish a

new overall workable schedule for the network. Conversely, a vehicle crew may have to ask by radio communication, for agreement on an increased time-lag if for any reason it has been delayed, or they may report they had to switch to a lower grade time-table (slower time-table).

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The following example illustrates a method for determining bij on the previously described network subdivided in 1000 meters blocks, for trains Hi and Hj sharing a common path EF. Referring now to FIG. 15, given the slow speed of Hi, the distant signal at point M being the first restrictive signal to affect Hi if Hj has not cleared point E, bij is computed as follows: bij=Tcj-Tci where Tcj is the time at which Hj clears point E and Tci is the time when Hi clears point M. For the sake of simplicity, the above example assumes that both trains have constant speeds. It should be noted however, that the same method applies to variable speed time-tables, with or without safety signaling. Interference limit conditions for a vehicle Hi following a vehicle Hj without having to slip off its assigned time-table may always be expressed in condensed form through two constant such as aj and bij.

Detailed Description Text (23):
In a second memory 9, are stored the instantaneous acceleration or deceleration commands to be applied to the vehicle in relation to the vehicle position px. These commands are also cross-related in the memory 10 to the times tx corresponding to the position px according to the assigned time-table. These acceleration or deceleration commands can be computed a priori and entered in the laboratory. Preferably they are recorded during an experimental run of the vehicle over the corresponding itinerary, according to the procedure illustrated in FIG. 13. During subsequent runs command datum .gamma.ex is extracted from the memory 9 in function of the position coordinate px issued by the dead-reckoning process 3, to which a correction factor corresponding to the product of the speed vx by the response time, TR of the vehicle to acceleration or deceleration commands is added at 8. Command datum .gamma.et is extracted from the memory 10 in function of the time te derived from the clock after adding the response time TR to the time Ti, in 7, so that te=tc+TR-TL. A selector circuit 13 allows .gamma.ex to reach adder circuit 14 only when .gamma.ex value is negative or corresponding to a deceleration command. The command .gamma.et is fed to adder 14 only when it is positive and corresponding to an acceleration command. The command data .gamma.ex and .gamma.et should theoretically be sufficient to allow the vehicle to faithfully duplicate the experimental or theoretical run the characteristics of which have been stored in the memories 2 and 9. However, the inherent inaccuracy of the various organs of the vehicles would tend to cause a drift away from the time-table schedule. An additional acceleration or deceleration component .gamma.x is thus generated in 12 in function of the time error .DELTA.tx according to the formula:

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Various types of distance measurement techniques and devices may be advantageously used within the scope of this invention. For the sake of explanation, an acceleration technique and a wheel revolution counter technique will be specifically discussed. The first measurement chain comprises a wheel revolution counter 15 associated with a long term drift correction circuit 16 to indicate the estimated distance travelled pc.

Detailed Description Text (27):

The second measurement chain comprises an accelerometer 19 which is located on the vehicle structure so as to give an indication of the longitudinal acceleration applied to it. In a train locomotive this accelerometer should be located near the center of the moving body in order to reduce the effect of the lateral acceleration experienced during the negotiating of curves. In order to compensate for slopes and suspension deflections, a tilting correction generated by a gyroscope 29 is added to the accelerometer 19 output. The acceleration data are fed to a first integrator circuit 20 at the output of which the speed vx of the vehicle is read and displayed at 26. A second integrator circuit 21 is used to obtain the estimated distance travelled py. An increment selector 23 periodically selects the distance increment indicated during the current measurement period from either pc or py. This incremented period may conveniently be in the order of one second. The selection function may be the sum of Q.sub.Pc and (1-Q).sub.Py where Q is the weight factor attributed to the revolution counter data. The selected increment is then added in 24 to the content px of a position display register 25 in order to generate the current position coordinates which is immediately entered into the display register 25 in place of the previous reading.

Detailed Description Text (28):
It should be noted that the wheel-revolution counter and the accelerometer constitute two measurement techniques which appropriately complement one another. The accelerometer usually gives a reliable measure but its twice integrated output signal is subject to drifting. It is known that during periods of high acceleration or on uphill ramps, the traction wheels of a vehicle are subject to spinning. During the deceleration process the wheels are subject to skidding. The revolution-counter is thus a poor gauge of the distance travelled during these periods; but can safely be relied upon during long periods of constant speed or of low power application, to provide precise measurement on the basis of which the accelerometer can be recalibrated. The increment selector 23 operates in function of the raw, absolute value of acceleration and gives more weight to distance increments from the wheel revolution-counter in inverse proportion to the amplitude of the accelerometer output. A comparator circuit 22 is further added in order to generate a correction factor for the accelerometer and the speed indicator 26 in function of the error detected between pc and py during periods when the wheel revolution-counter can be expected to yield very reliable data.

Detailed Description Text (33):
FIG. 9 also illustrates the block diagram of the process followed in correcting the slow drift error caused by variations in the wheel circumference due to wear and temperature variations.

Detailed Description Text (34):
The wheel circumference factor W (multiplied in 32 by the number of revolutions N indicated by the counter 15) is quasicontinually adjusted by a minute correction factor .epsilon. added to it at 33. The correction factor .epsilon. is a function of the correction C applied to the display register 25 upon detection of a check point. This correction is computed in the correction circuit 31. A low-pass, integrating type filter 30 may be advantageously installed between the circuit 31 and the adder circuit 33 in order to stabilize the corrective system loop. The exact location coordinates pex of each check point Ex can be determined by survey and written into the memory 17 in the laboratory. These coordinates can also be recorded during an experimental run according to the following procedure.

Detailed Description Text (39):
When identity of signals is found between the information extracted from the memory 17 and the information issued by the sensing equipment 38-39, the corresponding location coordinate Pxn which lies between Pxm and Pxr is transmitted to the correction factor generator circuit 36. In the correction factor generator circuit 36, the location coordinate Pxn is compared to the estimated location px and a correction value C is generated according to a function similar to that illustrated

by curve C of FIG. 8. The correction value is then added at 37 to the estimated position coordinate px. The resulting corrected coordinates are then entered into the display register 25. The correction value C is also used to reset the variable statistical factor used in the statistical limit circuit 34.

CLAIMS:

5. The method claimed in 4 which further comprises:

(a) recording in a memory during said experimental run, an identification code for each said event in coordination with its location of occurrence coordinates;

(b) reading at least one of said events identification code during subsequent scheduled runs from said memory according to an address margin determined in function of the estimated location coordinates held in said register combined with statistical factors which are modified in function of the current estimated accuracy of the coordinates held in said register;

(c) comparing the identification code of the event being detected with the identification code being read out from the memory;

(d) upon detecting similarity between said identification codes, generating a correction factor to be applied to the contents of said register where said correction factor is a continuous non-linear function of the difference between the coordinates stored in the register and the prerecorded location coordinates of the detected event.

8. The method claimed in claim 2 wherein step 2b comprises:

measuring said distance by means of at least one accelerometer, the output of which is twice integrated, and by means of at least one wheel revolutions counter, wherein the accelerometer generated data are given more weight during periods of acceleration and deceleration and the revolutions counter data are given more weight during periods of constant speed or minor acceleration and deceleration.

9. The method claimed in 8 which further comprises:

modifying the wheel circumference factor used to calculate the distance travelled from the wheel revolution counters data, by a correction factor adjusted periodically in function of the error between said data and measurement derived from at least one other means.

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	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L18	L17 and @ad<=20031126	21	L18
L17	L16 and (correct$ with (factor or coefficient) with wheel$)	30	L17
L16	L14 and (sens$ with (coordinate or position$ or location$))	276	L16
L15	L14 and sens$ with (coordinate or position$ or location$)	276	L15
L14	(train or locomotive) and (correct$ with factor) and wheel$	1095	L14
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L13	l11 not L12	9	L13
L12	L11 and ((verif$ or check$ or authentic$) with (identity or ID))	6	L12
L11	L10 and risk$	15	L11
L10	L9 and (security with clear$)	18	L10
L9	L8 and telephone	135	L9
L8	(securit$ with rating) and @ad<=20011012	254	L8

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L7	(securit$ with rating) and @ad<=20011012	162	L7
L6	L1 and (securit$ same (grad$ or rank$ or class$ or rat$))	0	L6
L5	L1 and (securit$ with (grad$ or rank$ or class$ or rat$))	0	L5
L4	L1 and (securit$ with rat$)	0	L4
L3	L2 and telephone	0	L3
L2	L1 and ((verif$ or authentic$ or check$) with arriv$)	1	L2
L1	6698653.pn.	1	L1

END OF SEARCH HISTORY